Aspects of Forest Management in the Austrian Tirol

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The Austrian Tirol, one of the nine provinces of the Austrian Federal Republic. has an area of 12,647 sq. km. and a population of 500,000 people. Its capital, Innsbruck, was founded on the old Roman road through the Alps which still serves as the main route between Italy and Germany. Topography is typically Alpine with snow capped mountains alternating with fertile green valleys or *tals*. Its forests, which account for 37% of the land surface are located mainly on the mountain slopes and ridges.

FOREST OWNERSHIP AND ORGANISATION

Forest ownership is divided into 22% Federal Forest, 42% Community Forest, *(Agrigemeinschaft)*, 34% Small Private Woods, and 2% Large Private Woods. The Federal Forest is the responsbiility of the Ministry for Lands and Forests based in Vienna. In the Tirol the forest area which it controls is divided into 16 districts of 5,000 to 10,000 ha each. The District Officer who incidentlly is employed on a contract basis and is not a civil servant, has complete responsibility for the management of his district and according to law the Federal Forest must be managed by the same basic business principles which apply for private enterprise.

Management of the community and private forests is the responsibility of the Tirol Province Forest Service, which operates within the framework of the forest legislative code laid down by the Federal Forest Service for all of Austria. There are 19 Provincial forest districts in the Tirol, each in the charge of an academically trained forester. Districts vary in size from 12,000 to 30,000 ha and are divided into a number of *revieres* controlled by *reviere* foresters who are assisted by forest supervisors *(Waldaufseher)*. (A *Waldaufseher* has had a six months training in forestry and on average there is one in every medium sized village). Since the Province does not own the forest the role of the forestry personnel is somewhat analogous to that of the Agricultural Advisory Service in this country, but in a forestry context. There are, however, Provincial forest laws governing the management of both community and private forests which ensure that

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owners comply with the precepts of the management plan prepared by the Tirol Provincial Forest Service.

SILVICULTURAL PRACTICES

The Austrian Tirol is the meeting place of two of Europe's major climatic zones, an Atlantic type of climate north of the Inn river and a Continental climate to the south.

From a silvicultural point of view the two have important differences. Frequently, both zones occur on opposite sides of the same valley as illustrated by the Atlantic climate of the Hafelekar mountains overlooking Innsbruck from the north and the Continental climate of Patscherkofel to the south. The essential difference is due to aspect and rainfall. Slopes with a southern aspect have a significantly higher rainfall than north facing slopes. The Atlantic climate favours species such as Norway spruce *(Picea abies)*, silver fir *(Abies alba)* and beech while, in the Continental zone, the silver fir and beech are replaced by *Pinus cembra* which needs cold winters for germination. European larch is also present in mixture with the spruce. The silvicultural system most widely practised is the *Saumschlag* (strip system) which involves cutting a 20 m strip every 5 to 10 years after a preliminary regeneration felling. (Essentially this is closer to the *Shirmsaumschlag* or shelter-wood strip system). In the Continental climatic zone every effort is made to obtain a mixture of larch or pine with the spruce as a precaution against wind-throw. If the strip is too narrow there is insufficient light for larch to regenerate; too wide a strip will allow grass to develop and natural regeneration may be impossible. Failure to regenerate naturally is silviculturally undesirable because it means planting with a sub-species or provenance which may be completely unsuited to the site. This is more readily appreciated when it is considered that four sub-species of spruce are recognised; these with pendulous branchlets for the valleys and lower slopes, these with flat branches for the middle slopes, the brush type *(burste)* for the higher slopes and the narrow crown pinnacle type *("spitz")* spruce for the highest regions. Since the different sub-species are indistinguishable in the transplant stage the importance of natural regeneration becomes apparent. Planting of the pendulous branch type on a *"spitz"* spruce site would be disastrous. Similar sub-species exist for pine.

In the Atlantic climate zone the strip system is also the most widely recognised method of regeneration. In theory regeneration with Norway spruce, silver fir and beech should present no problem. In practice, however, regeneration is often impossible to achieve where cattle are allowed to graze. In Achental, for example, 5,300 head of cattle grazed on 6,000 ha of woodland and natural regeneration was non-existent except where fencing was

erected. In ungrazed areas natural regeneration in the proportion; beech 2, silver fir 3, norway spruce 5, is the objective. The proportion of the stand to be removed in the regeneration felling will vary depending on aspect and amount of light reaching the forest floor. In one instance 60% removal on a northern aspect failed to achieve natural regeneration. Then the remaining 40% was removed and regeneration came into profusion.

PRODUCTION AND HARVESTING

The forests of the Tirol are sub-divided into two broad categories, production forest and protection forest. The property of the Federal Forest Service at Achental contains 4,630 ha of production forest and 1,703 ha protection forest with an average standing volume of 221 cubic metres per ha for the production forest and 163 cubic metres per ha for protection forest. The weighted average is 206 metres per ha. Length of rotation ranges from 100 to 120 years. Mean annual increment in Achental varies with species and district from a minimum of 2 cubic metres per ha per annum to a maximum of almost 6 cubic metres per ha per annum. In more fertile districts the mean annual increment can range from 6 to 10 cubic metres per ha per annum, but this is above average for the Tirol. Growing stock is determined at 20 year intervals by systematic sampling on a line plot basis. The allowable cut is determined by Von Mantel's and similar formulae and is currently 800,000 cubic metres per annum for the Tirol.

Topography makes the extraction of timber a difficult and costly operation. In former times chutes and sleds were used to bring logs to the lower slopes where they were loaded on horse-drawn vehicles or stream driven if there was a stream with sufficient water. Occasionally forest railways and aerial ropeways were used. In general, however, the erection of an aerial ropeway of the Wyssen type as used in Switzerland is ecomically unattractive because of the cost of erection and the requirements in regard to total volume and quality of material to be extracted. Good quality roads are considered to be the solution in the long term.

Where short-haul extraction to roads is feasible, as in Achental, the following procedure has evolved. Four men fell with chain saws; six to eight men operate Garret Tree Farmer vehicles to drag the logs to a central depot within the forest where they are put through a debarking machine. A forester and his assistant supervise the operation, one co-ordinating at the logging point and one measuring and segregating material into assortments at the depot. The group has a mechanic available in case of breakdown and the total number in the group is twenty. Using this approach the total cost per cubic metre has been reduced from 158 Sh by the conventional method to 115 Sh (from 9½p./cu. ft. to 7p./cu. ft.).

Roads are constructed to a high standard to cater for truck and trailer loaded to a gross weight of 38 tons—the legal limit. Construction is carried out in winter by bulldozing a road foundation of approximately $\frac{2}{3}$ cut and $\frac{1}{3}$ fill depending on the underlying material. In Achental district the cost of roading ranged from 240 to 270 Sh/mt. (Approximately £7,000/mile). The high cost was attributed to a soft subsoil and the fact that the rough and fine surfacing material has to be transported 4 km and 8 km respectively. Road density it 30 m per ha.

Felling and sort-haul extraction is done by forest labour. Material is sold on roadside at 750 Sh per cubic metre (41p/cu. ft.) for sawlog material and 350 Sh per cubic metre (19p./cu. ft.) for pulpwood. The method of sale, by auction, sealed tender or private treaty, is left to the discretion of the district officer who has responsibility for all matters that relate to his district. This includes road alignment and construction, wildlife management and protection, and the determination of when, where and what to cut as well as sale of the produce. Since Federal Forests operate under the same criteria which apply in private enterprise, management proposals submitted by the District Officers to Headquarters in Vienna come under close scrutiny and only those which indicate a reasonable return on investment will be sanctioned. This practice can sometimes lead to considerable reward. Up to seven years ago the Achental district was losing money, at which time the District Officer submitted a proposal for a roading programme which was underwritten by the Vienna headquarters. Now the district has an operating surplus of 3 to 4 million Sh per year and this is expected to continue.

WILDLIFE MANAGEMENT

In the Tirol the management of deer is considered an integral part of Forest Management. The forest is rented in hunting *revieres* and the following table illustrates the size of *reviere* and rental perha per annum in the Achental.

Name	*Area in Ha*	*Rental—Sh/Ha*
Bachental	6,568	23
Klammbach	1,456	25
Hechenberg	1,067	43
Dollsmannsbach	867	30
Seekarspitz	1,126	30
Pitz	1,186	30

In addition to the rental per ha there is a charge to cover the cost of foddering deer during the winter months. In Klammbach this

is currently 162 Sh per ha to give a total charge of 187 Sh per ha. Here fifty-two red deer were fed last winter on silage, hay and concentrates which included vitamins A and D. The amount of foddering depends on the weather. When the snow is heavy the deer find it difficult to move through the mountain ranges. Generally foddering lasts approximately 170 days from October to May and the daily ration per head is 6 kg silage, 2 kg of hay and 0.6 kg concentrates.

In addition to foddering, wet areas are reclaimed for grass and meadow is rented from local farmers to give 1% to 2% of the total area as "deer lawns." Regenerated areas in the 1 to 20 years age class are also counted as grassland and areas over 100 years are given as $\frac{2}{3}$ of their actual acreage. The objective is to prevent damage to natural regeneration by deer where there are 6 head per 100 ha as in Klammbach. The normal stocking is 1 to $1\frac{1}{2}$ per 100 ha. In areas where natural regeneration is prolific a stocking of 2 to 3 red deer and 5—6 roe deer per 100 ha is possible. A stocking of 10 red deer per 100 ha generally leads to the disappearance of the silver fir which is eaten in the seedling stage. In natural woodland the silver fir occurs in mixture with Norway spruce in the proportion 40%—40%. With high stocking of red deer the proportion becomes silver fir 10%and norway spruce 80%. Many foresters have claimed that the disappearance of silver fir is a natural phenomenon because there is no apparent regeneration of silver fir. They are not aware that it is eaten in the seedling stage. This can be proved by shooting the deer and examining the contents of the rumen. Generally, where the stocking is high the deer are usually young animals. This is a bad situation as hunters prefer to shoot older deer and the young have no teachers to show them what to do.

In winter the herds are counted and the shooting plan is drawn up in May by the district staff. In Klammbach the 1970-71 count showed 154 red deer, 57 roe and 70 chamois. The shoot of red deer in 1971 will be 3 stags over 10 years of age, 15 younger ones and 35 calves and hinds. The general recommendation of the shooting guide is to remove 50% of the calves, 25% of 1 to 5 year old and none of the 5 to 10 year old. The aim is to have 50% of the red deer stags more than 5 years old. Red and roe deer are shot in the ratio 1 male to 1 female and chamois 1 male to 1.2 female. The following table outlines the shooting season for red and roe deer and chamois.

Red Deer:

Hinds, 1 year calves	1st July—31st Dec.
Young stags IIb	1st Aug.—31st Dec.
Young stags	31st Aug.—31st Dec.
Old Stags Ia, Ib	16th Aug.—31st Dec.

Roe Deer:

Roebuck	16th June—31st Oct.
Female Roe and kids	16th June—31st Dec.

Chamois: 1st Aug.—15th Dec.

Hunters are rarely allowed to go into the hunting *revieres* alone unless they are very experienced. They are allowed to keep the meat of the kill and there is no extra charge for the trophy. Renting of a hunting *reviere* by a syndicate is frowned upon and in the Achental only two persons are allowed to combine in the renting of a hunting *reviere*. In addition to red and roe deer and chamois hunting *revieres* have good numbers of capercaillzie *(Auerwild)* and Black Grouse *(Birkwild)*. In 1958 an experiment was launched to establish a colony of *Ibex (Steinwild)* in Bachental. Today they number 29 after the loss of three in an avalanche in the winter of 1969/70. The Red Deer Preservation Association, *"Karwendel"*, was established in 1962 to improve the structure and raise the quality of the herds. To date, the results achieved have been extremely good. In Achental, since the Spring of 1970 a programme of wildlife research is being conducted under the well-known game biologist, Dr. Bubenik. The objective is to investigate the movement of deer in relation to time and area and determine the dependence on infrastructure and environmental factors.

PROTECTION FOREST

In former times the people of the valleys cleared trees from the timber line first to provide summer grazing for their animals. As the population increased people moved up the slopes and the timber line moved down. The grazing sequence for cattle is a movement to the higher elevations (2000 m) in the summer, to the middle slopes in autumn, to the lower slopes in the late autumn and back up to the middle slopes where they are fed and housed for the winter months. Grazing of the woodland areas and the constant cutting of vegetation and branches for animal bedding has resulted in degradation of both the alpine meadows and the forest.

The formula; Precipitation = Evapo-transpiration + Run-Off + Percolation expresses the water balance between the atmosphere and the ground. It is well known that closed woodland reduces or may even eliminate run-off and thereby reduce erosion and by delaying the flow to water courses checks or prevents floods. Furthermore, snow melts more slowly under trees and the melt-water is unlikely to exceed the absorptive capacity of the litter on the forest floor and the soil beneath (1). The forest is therefore an important factor in the Tirol in the effort to prevent

avalanches in the winter and spring and combat torrents in the late summer and autumn.

Avalanches are of two kinds; the wet avalanche is caused by the movement of wet snow down a slope and trees can play a signifiant part in preventing its occurence or checking the movement. Dry avalanches occur after a heavy fall of dry snow on sloping ground. The force holding the molecules of snow together is overcome by the force acting down the slope. As the snow breaks away to form the avalanche there is a tremendous release of energy giving off an explosive sound and the avalanche hurtles down the slope creating an air cushion in front which uproots or breaks trees. The force which it exerts on an object in its path is reckoned at 100 tons per square metre. This type of avalanche usually forms above the timber line and when it strikes it leaves a swathe through the forest on the lower slope. Since little can be done to stop it the objective is to prevent it. This is done by using rockets or explosives to bring down the snow before it can build up to avalanche proportions. In the long term the raising of the timber line will provide a more adequate and less costly form of protection against avalanches than the existing steel barriers and nets. This work is the responsibility of the Tirol Forest Service and the current work being done in the Zillertal demonstrates the approach adopted.

The Ziller river rises in the glaciers of the Zillertal Alps on the Austrian-Italian border and flows north into the Inn through the Ziller Valley for the greater part of its course. The "*integralmelioration*" project being conducted for the 197 sq. km. on the left side of the Ziller Valley has to date cost about 128 million Sh. The Federal Government provides 70% of the cost and of the remainder 20% is provided by the State of Tyrol and 10% by the community. A large proportion of the fund is spent on controlling the small tributaries which flow down the valley side into the Ziller. In the past the small towns and villages were erected on those tributaries as they provided the only source of power. During periods of heavy rainfall those small tributaries can become raging torrents which transport thousands of tons of debris and deposit it in the valley. These torrents consist of 40% water and 60% material ranging from fine silt to boulders weighing more than a ton. The deposition of the material interferes with the flow with the result that it spreads out from the stream bed causing extensive damage to property and sometimes resulting in deaths in the villages and towns. Initially, dams were erected to create small lakes where the material could settle and be removed later. These dams were, however, only adequate for the control of small torrents and in some instances the settling area filled up in less than 15 minutes so that the remainder of the torrent went over the dam. More recently, the trend has been towards the erec-

tion of barriers consisting of horizontal steel girders bridging the stream and set in concrete and stone piers. A three barrier battery of this type protects the town of Fugen in the Zillertal. The first barrier has the girders 1 m. apart so that anything exceeding 1 m. in diameter is held. The next barrier has girders 60 cm. apart and the third has girders 30 cm apart so that each in turn will trap material larger than 60 cm and 30 cm respectively. The 30 cm spacing of girders in the third barrier is conditioned by the fact that the Ziller can move material up to 30 cm in diameter.

In addition to the erection of barriers much work is being done to reduce the speed of the water flow in the streams and consequently its potential for erosion. This is achieved by constructing a series of steps along the steeper stretches.

The contribution of the Forest Service *(Forstinspektion)* in the drive to re-afforest the high alpine meadows is illustrated on a 200 ha commonage near Fugen. Altogether there are 30 to 40 owners who have agreed to the re-afforestation of 160 ha of the 200 ha in return for amelioration of 40 ha. The results have been striking; the total milk yield formerly obtained on the 200 ha has been doubled and the quality has improved. In addition a new road network has improved communications and marketing arrangements for milk and milk products are better. Stock has been excluded from the 160 ha and the area has been planted with *Pinus cembra,* European larch and Norway spruce at a stocking of 5,000 plants per ha costing 15,000 Sh per ha. The objective is to raise the timber line from 1600 m to 2100 m and abolish grazing by cattle in the existing production forest. This is expected to increase increment from 1 to $1\frac{1}{2}$ cubic metres per ha to 2—$2\frac{1}{2}$ cubic metres per ha. The Forest Service is very pleased with the success of this project and now has data to prove that amelioration of part of the area can free the remainer for re-afforestation. Convincing the owners of the feasibility of such projects will be less difficult.

The re-afforestation of the high alpine meadows is a task of great difficulties, not the least of which is the heavy failure rate due to extreme exposure. In an attempt to overcome this problem a small nursery has been established in the Zillertal at 1700 m to produce plants for high altitude afforestation. Larch and *Pinus cembra* seedlings, 1 year and 2 year old respectively, are brought up here for transplanting and remain for a two year acclimatisation period before being planted. In the Sellraintal there is a further problem of too much or too little snow to contend with. Too much snow results from movement of the snow by wind into drifts, the location of which depends on the configuration of the ground. Other areas are stripped bare of snow in the process and the plants suffer from frost damage. A great depth of snow creates ideal conditions for the snow fungus, *Phacidium infestans*

and when the slope is steep the snow has a tendency to creep down the slope ripping out plants in the process. In an attempt to prevent this ripping out of plants, snow-bridges have been erected over the plants or the ground has been stepped to create a flat location for the plants. The major problem of uneven snow distribution has been overcome by the erection of screens at strategic points to control the wind speed. A screen with 50% open space will give a flattish distribution of snow to leeward while a screen with only 25% open space gives a much more peaked distribution closer to the screen. Screens of iron, aluminium and plastic have been tried and to date the best results have been obtained with the plastic type 50% open. The Sellraintal was at one time a continuous closed forest but was deforested 1,000 years ago for the purpose of obtaining pasture. The cost of re-afforestation is borne by the State (80%) and the owners (20%). *Pinus cembra* and larch are the species used at a density of 6,000 plants per ha on good sites and 10,000 to 15,000 plants per ha on poor sites.

It is now recognised that a large proportion of avalanches and torrents can be attributed to the lowering of the tree line in former times to provide alpine meadows for grazing. While protection against avalanches and torrents can be effected by technological methods such as nets and barriers, this a very expensive approach and is limited in practice to strategic areas. In the long term the solution lies in restoring the tree limit to its former position, but this is a very difficult undertaking without scientific research. The *"Klimahaus"* on Patscherkofel mountain south of Innsbruck is one centre of the Alpine Forest Research Institute investigating the problems involved.

At Patscherkofel, Professor Tranquillini of the University of Innsbruck and a staff of twenty conduct research into aspects of climatology, plant physiology, soil science etc. associated with the survival and growth of plants at high altitudes. Young plants are examined to investigate their resistance to varying climatic conditions such as freezing temperatures, heat, desiccation, etc. Since the weather is very extreme at the centre many plants fail to survive. On the open mountain it is impossible to determine the cause of death or, indeed, to say when the plant died. In the *"Klimahaus"* it is possible to take one factor at a time, e.g. there is a room where freezing temperatures can be simulated.

Working with with different species, such as *Pinus cembra, Larix* and *Picea,* their response to various factors can be determined. For example, fertilization with nitrogen gives big plants with very poor resistance to freezing temperatures. These will die on the tree line. The second research objective in the *"Klimahaus"* is to determine the material production of plants: they must not alone survive, they must grow to be of use. The relationship between growth and climate is important so it is essential to grow

plants and measure the rate of growth. Since this would take years to accomplish, an alternative method has been evolved in the form of measurement of carbon dioxide uptake. This method is expensive in practice, but it is exact. After a few minutes it is possible to say how much material the plant will produce.

The relationship between production and temperature for *Pinus cembra, Larix* and *Picea* is also being investigated. The production surve for Patscherkofel, at 2000 m above sea level, shows an optimum at 12°C and differs markedly from that at Innsbruck 1,500 m below it in the valley.

Wind is another important factor which influences production. With tree species, greater production is obtained with low wind speed which gives a higher carbon dioxide gradient than zero wind speed. With greater wind speed the stomata close and production decreases. The sensitivity of Rhododendron to even moderate wind speed is apparent from the abrupt decrease in production with increasing wind speed.

—Experiments with shoot and root anti-transpirants have shown considerable success and results have been put into practice in the field. In particular, the application of an alginate (agricole) to plant roots after lifting has given good results. Planting check is diminished and survival is much improved. In the *"Klimahaus"* research is in progress to determine the relationship between root respiration and photosynthesis of shoot and next year fifteen different provenances of spruce will be tested to establish this relationship for each one. The relationship between respiration and photosynthesis of shoot can be established for varying intensities of temperature, humidity and light in an intricate home-made apparatus. Essentially, it is a question of measuring the carbon dioxide content of the controlled atmosphere at different levels of these factors. Professor Tranquillini considers that the best pioneer species is larch but at the tree line the only species worth considering is *Pinus cembra.* A New Zealand research worker at Patscherkofel had no success with *Pinus contorta* from New Zealand.

RECREATION

The Tirol is well known as one of the leading ski-centres in Europe and the demand is such that forestry loses 50 ha per year to ski-runs. An equivalent area is, however, planted elsewhere to maintain the balance.

In the vicinity of Innsbruck there is a network of paths through the forest to facilitate hiking or mountain climbing. Most of those paths have been formed over the years by people seeking recreation. On the outskirts of Innsbruck a forest walk of 2.5 km long has been created in the "Hottinger Hofbannwald" at the foot

of the "Nordkette" and more recently a "Forest meile" has been created at Gotzens which includes a series of exercises in the recreational facilities offered.

The role of the forest in contributing to amenity is very important in the Tirol because of tourism and it is fortunate that the silvicultural system adopted by choice (the strip system) causes a minimum of disturbance of the landscape. Whether this can continue in the future remains to be seen. Rising costs and economies of scale may force the logging of larger areas in the interest of economic forestry. Amenity will then act as a constraint and may indeed limit any development in that direction. Since many of the private forest owners are also involved with tourism in that they provide accommodation, they may willingly decide to forego revenue from the forest in order to maintain the unique amenities which now exist.

REFERENCE

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